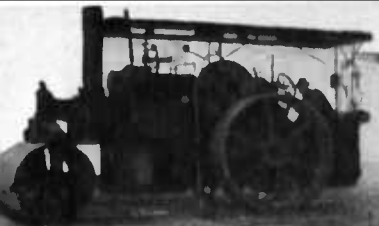


Steam Sterilization of Seed Beds for Tobacco and Other Crops

E. G. BEINHART
Assistant in Tobacco Investigations

FARMERS' BULLETIN 996

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Plant Industry

WM. A. TAYLOR, Chief

Washington, D.C. July, 1918

THE TOBACCO SEEDLING is subject to injury in the seed bed by weeds and a number of parasitic enemies, among which is a fungous root-rot. It is of the utmost importance to secure beds free from weeds and to avoid the use of diseased or weak seedlings. Methods of sterilization have been developed to control seed-bed conditions. The old method of open fires, long practiced in the South, is being replaced by a steaming process the essential feature of which is an inverted pan used to force the steam into the soil. This method of steaming has been widely adopted in certain tobacco-growing districts and is applicable to most, if not all, of them. The process of steaming described is the most practical and economical method of seed-bed control yet developed, and besides eliminating diseases and improving general soil conditions, it kills weed seeds more effectively than the old methods. The cost of sterilizing is more than paid for by the saving in the cost of weeding.

This bulletin describes the necessary equipment and method of operation, with certain special features of seasonal convenience and seed-bed preparation. The method is applicable for working on either small or large seed-bed areas and can be used in all tobacco-growing districts.

With necessary modifications in the apparatus which will readily suggest themselves to the truck grower, the method can be used very successfully to control soil conditions in the greenhouse, in cold-frames, or in the field.

STEAM STERILIZATION OF SEED BEDS FOR TOBACCO AND OTHER CROPS.

CONTENTS.

IMPORTANCE OF VIGOROUS TOBACCO SEEDLINGS.

IN TOBACCO PRODUCTION, to grow the right sort of seedling plants is of special importance. Successful transplanting from the seed bed to the field requires vigorous seedlings, and the growth of the crop in the field, especially in the early stages, is largely dependent upon the character of seedling used. Great importance is to be attached to securing strong, healthy seedlings. The young plants in the bed are liable to be injured, and therefore it is necessary to protect them from parasitic and other enemies, which may injure and retard their growth or even kill them. Chief among these enemies are weeds and certain fungous diseases, especially root-rot. Spots in the beds are also frequently found where the soil conditions are such that normal development can not be attained.

These difficulties can be eliminated or greatly reduced by the sterilization of the seed beds, which now is recognized as an important feature in tobacco growing. Seed beds are sterilized for the control of diseases and to kill weed seeds and hibernating insects. When properly done, the saving in weeding costs usually pays for the whole operation of sterilization. The process has the additional advantage of insuring freedom from diseases and the production of more vigorous seedlings.

Sterilization by surface burning has been widely practiced for generations in the South, and in fact has been used at one time or another in nearly all tobacco districts. In the southern districts it has been customary to select each year a new location for the seed

bed, and the chief object of burning has been to free the bed from weed seeds.

In the northern districts permanent seed beds with glass covers are in more or less general use, and the widespread appearance of fungous diseases, especially root-rot, has made some sort of sterilization necessary. Since open fires are impracticable in these districts a process of steam sterilization has been worked out, which now is used extensively in the cigar-leaf producing districts of the Connecticut Valley, Pennsylvania, and Wisconsin and has been employed with success in several other sections, notably in western Kentucky and Tennessee and in the Burley district. This method is both economical and effective, and with more or less modification is adapted to practically all tobacco-growing districts.

ROOT-ROT IN THE SEED BED.

Within recent years the discovery of the prevalence of a root-rot in the seed bed and in the field has brought about a wide demand for a suitable method of control. The fungus[1] which causes this root-rot is so small that it can be seen only with the aid of the microscope. It may attack the plant at any time after the germination of the seed, and usually can be recognized easily by its effect upon the roots. In the earlier stages brown or black spots appear on the roots. These vary in size from small dots to areas that may extend along the taproot and laterals for an inch or more. In these diseased portions spores, or reproductive bodies of the fungus, may be found by examination with the microscope. As the fungus attacks the roots the diseased parts become successively brown and black, and the root tissues die and fall away, seriously affecting the vitality of the plant.

The fungus lives in the soil from year to year; hence, a bed once infested should not be used again until the disease has been eliminated. New seed beds may be infected by stable manure or decayed leaves used for fertilizing, or by wind-blown vegetable matter carrying spores of the fungus. Seedlings seriously attacked by root-rot are not fit for transplanting, and, furthermore, they may be the means of establishing the disease in the field. It is especially important, therefore, that the disease be eliminated from the seed bed. An effective and economical method of control of the root-rot in the seed bed is found in the sterilization of the seed-bed soil.

OLD METHOD OF STERILIZING TOBACCO SEED BEDS.

For many years before the adoption of sterilization with steam, open fires on the soil had been used. The open-fire method came into use chiefly because of its value in freeing from weed seeds the spot

[1] The technical name of this fungus is *Thielavia basicola*.

selected for the seed bed. It has been practiced for a great many years in the tobacco-growing areas south of Maryland and Ohio, where it is common to locate the seed bed at the edge of or in the woods. The area selected for use as a seed bed is cleared, the ground broken, and brush and wood laid over it and burned. The degree of thoroughness with which the surface burning is done in different sections depends on the character and quantity of the fuel supply and on other local conditions. When the burning is done thoroughly the resulting heat is sufficient to free the soil of all fungi and weed seeds to a depth of several inches, but the organic matter of the soil is largely destroyed, and later the surface of the bed is likely to bake during even short dry periods, killing a large percentage of the seedlings.

Barn manure and fertilizers containing organic matter must be applied after firing to prevent their decomposition in the burning, and this opens the way for adding to the seed bed material carrying fungous spores or weed seeds. If excessive quantities of ashes are left on the bed the growth of the seedlings may be affected, and sometimes the germinating seed may be killed.

In order fully to accomplish the purpose of burning, it is necessary to secure a high heat over the surface of the entire seed bed. This requires large quantities of wood, and the ever-increasing scarcity of wood in certain localities has made it practically impossible longer to pursue this method.

A modification of the open-fire method is found in the portable wood-burning furnace. This furnace consists of a heavy fire box, 9 feet long, 3 feet wide, and 18 inches deep, constructed of iron and set close to the ground. On top of this is set a pan 9 by 3 feet and 10 to 12 inches deep. The whole apparatus rests at one end on a pair of wheels and at the other end on two legs. It is furnished with two handles for lifting and drawing. A fire is made in the fire box and the soil from the seed bed, to a depth of 4 or 5 inches, is shoveled into the pan and covered. The heat from the fire below brings about thorough serilization. While more effective than the open fire on the bed, the furnace has the disadvantage of being slow in operation and equally expensive in fuel consumption. It also necessitates a second handling of the soil.

THE STEAM-PAN METHOD OF STERILIZATION.

The steaming of the soil is the most satisfactory method of sterilization which has been developed up to the present time. The direct application of the steam to the soil by means of an inverted pan or hood has now been in successful operation for a number of years.[1] Thus far

[1] This method has been briefly discussed in Farmers' Bulletin 343, "The Cultivation of Tobacco in Kentucky and Tennessee" (1909), and in Bureau of Plant Industry Bulletin 158, "The Root-Rot of Tobacco Caused by Thielavia Basicola" (1909).

this process has been most extensively employed perhaps in the Connecticut Valley, but because of its many advantages and its effectiveness it is being widely adopted in other tobacco-growing districts.

PREPARATION OF THE SEED BED FOR STEAMING.

The seed bed is thoroughly prepared in the usual manner for sowing the seed. The soil is well worked, the fertilizers spread and mixed in the soil, and the bed brought to fine tilth, so that after the steaming is completed it is only necessary to rake the bed lightly before sowing the seed. It is important that nothing but the seed and the diluting material, also sterilized if necessary, should be added to the bed after sterilization.

A comparatively dry bed is the first requisite for successful steaming, as it is practically impossible for the steam to penetrate wet soil. Glass-covered beds may be dried with comparative ease by covering them with sash several weeks before steaming. The bed is protected from the rains and snows of spring, and the sun's rays warm the soil and drive off excessive moisture. Cloth-covered beds may be protected for two weeks before steaming when rain or snow threatens by stretching over them cloths which have been painted with a thin mixture of linseed oil and drier.

EFFECT OF FROST IN THE SOIL.

The presence of frost in the surface soil retards the penetration of the steam and makes it necessary to continue the process for an unusually long period. The ground must first be thawed before the desired heating can be brought about, and this causes a fuel consumption more than double that required where the soil is in proper condition. Where there is frost in the surface soil the steam does not penetrate more than a few inches, because of the condensation of the steam in the cold ground.

In order to thaw out the seed beds before steaming, a good practice is to cover them with glass for several weeks, as has been suggested for wet beds. The glass allows the heat from the sun's rays to be confined within the bed during the day, warming the soil and putting it in a mellow condition. Without such preparation even partial sterilization would be impossible in some sections till late in the spring.

FALL STEAMING OF THE SEED BED.

Steaming has been done in the fall by many growers because of the disadvantages experienced in the spring due to rains and snows or the frozen condition of the ground. Usually the seed-bed soil can be put in excellent condition in the fall when the land is dry and before the air temperature is low enough to freeze the ground. An

added advantage is found in the seasonal distribution of labor, making it desirable to do the work at this time, when there is no particular rush to complete the steaming.

Fall steaming has the disadvantage that infected material and weed seeds may be blown into the beds during the winter, but where windbreaks of high, tight board fences are placed around the beds this disadvantage is reduced to the minimum. There also is the added disadvantage in certain cases, particularly where the seed beds are located on low ground, of the ground becoming flooded during winter or spring thaws. The surface water may carry spores from adjoining infected land to the sterilized seed bed. It is necessary at all times to have thorough drainage in and around the seed beds.

Especially in regions of clay soils where glass frames have not come into general use fall steaming finds particular favor because of the practical impossibility of drying the seed-bed soil early enough in a wet spring.

Where the work is done in the fall all preparations are made as for spring steaming. If manure is used, the quantity added in the fall should be a little more than that ordinarily used in the spring, because of the possible loss by leaching. Commercial fertilizers can be applied safely in the spring.

EQUIPMENT NEEDED FOR STEAMING SEED BEDS.

The equipment recommended for steam sterilizing seed beds under average conditions consists of the following:

A portable boiler of 20-horsepower or larger capacity.
Heavy ¾-inch steam hose, 25 feet.
Iron ¾-inch pipe sufficient in length to carry the steam from the boiler to all parts of the beds.
Heavy canvas or burlap, 216 square feet.
A steaming pan to cover an area of about 72 square feet.
Attachments for the steaming pan, consisting of 4 ring bolts 6 inches long, with 3-inch rings; 4 bars or ax handles; felt packing 2 inches wide, sufficient in length to extend around the pan; the same length of 4-inch hoop iron or of 2-inch angle iron; one ¾-inch nipple 6 or 7 inches long, threaded on both ends; two ¾-inch leather gaskets; two ¾-inch nuts or threaded washers.

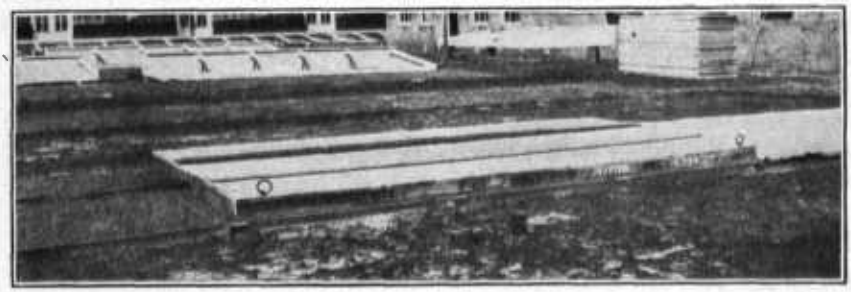
The boiler is the item of greatest expense, the rest of the equipment being comparatively inexpensive. With proper care the entire apparatus should last for a number of years.

A boiler of sufficient capacity is the essential factor in successful sterilization, because large volumes of high-pressure steam are required. Experience has shown that a boiler of at least 20-horsepower is necessary for efficient steam production when using a steaming pan of the size mentioned above. In some localities, where seed beds have been sterilized with steam for a number of years, farmers are

supplied with their own boilers; in other places one boiler is used cooperatively by several planters. Road rollers, steam tractors, and packing-house boilers are frequently called into use for seed-bed work. In some sections the owners of steam tractors or portable boilers go from place to place, sterilizing beds at fixed prices. Such operators are usually supplied with all necessary equipment, though sometimes they provide only the boiler and a fireman.

CONSTRUCTION OF THE STEAMING PAN.

In the permanent seed bed the pan is of such width as to fit snugly within the sides of the frame, and its length varies according to requirements. A pan having an area of 72 square feet is sufficient for a 20 or 25 horsepower boiler, and a larger pan is difficult to move. On a bed 6 feet wide the pan should be 12 feet long. Where only a



P1811T

FIG. 1.—Inverted wooden pan for the steam sterilization of seed beds, showing the connection of the steam hose. Note the fine preparation of the seed-bed soil. A light raking only will be necessary before sowing the seed, as all fertilizers are applied before steaming.

small boiler is available, the area of the pan should be correspondingly reduced, so that the boiler can maintain the desired pressure of at least 80 pounds.

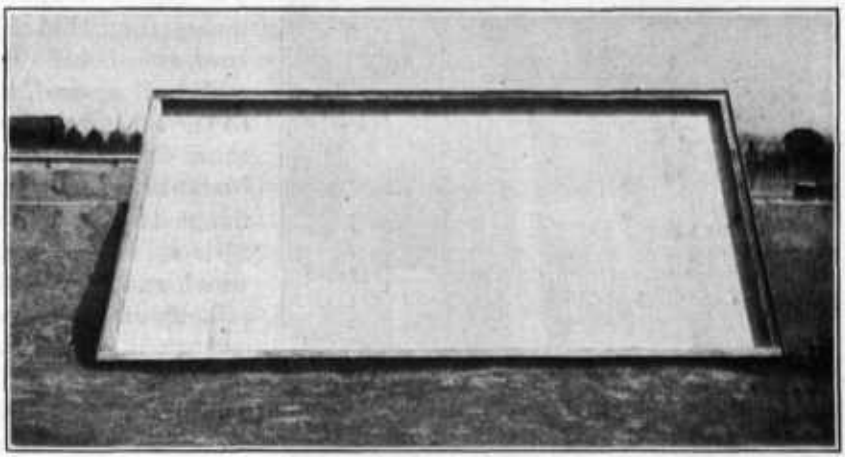
Sterilizing pans made of galvanized iron have been extensively employed, but as wooden pans are cheaper and are easily made at home, wood is the material now coming into general use. The wooden pan further possesses the distinct advantage of reducing the loss of heat by radiation.

The pan is simply a shallow box, 4 inches being the preferred depth. If it is deeper, much of the desired effect is lost through the more rapid cooling of the steam in the larger space exposed above the soil. The frame is made of 2 by 4 inch material; across this are laid matched boards ($\frac{7}{8}$ by 4 inches). It is advisable to put white lead in the grooves to prevent the escape of steam. The boards must be securely nailed in the tongue and at the sides to prevent drawing, as they swell by absorption of moisture during the process of steaming. These cover boards are further secured by two boards or planks

which are laid over them on the outside, at right angles to them, extending the length of the box, and which are very securely nailed at the ends (fig. 1). The cover boards are then nailed from the inside to the outside planks, the object being to prevent the swelling and warping of the cover boards. A good view of the inside construction of the box is shown in figure 2.

Two ring bolts are set in each side of the frame on the top, one near each corner. Through the rings ax handles or bars are thrust to serve as handles in moving the pan along the bed, as shown in the title-page illustration.

A strip of ¼-inch felt packing, 2 inches wide, is placed along the lower edge of the frame, on the outside, to prevent the escape of the steam. The hoop iron is then laid on the packing and



P1609T

FIG. 2.—The under side of a wooden sterilizing pan made of 2 by 4 inch frame and ⅞-inch matched cover boards. Hoop iron laid over thin felt and lapped over the edge surrounds the outside of the frame, forming a knife-edge joint in the soil to prevent the loss of steam. A ¾-inch nipple is inserted in one end, through which the steam enters.

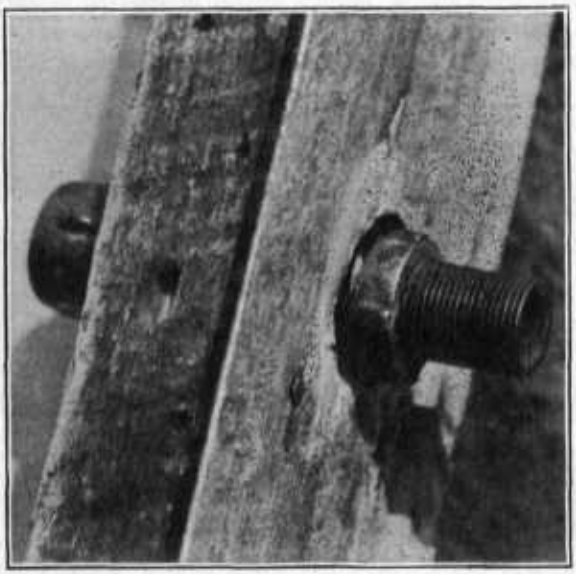
nailed every 4 inches, one-half its width extending beyond the lower edge of the frame, as shown in figures 2 and 3. When the packing can not be had, the iron is nailed to the inside of the frame instead of the outside. Instead of the hoop iron, 2-inch angle iron is sometimes used. This is fastened to the lower side of the frame, to form a tight joint when the box is laid on the soil. A piece of thin packing serves to prevent the escape of steam between the iron and the bottom of the wooden frame to which it is nailed. Angle iron, because of its heavier character, will not bend and is better than hoop iron, but it requires careful working to fit it to the frame.

In the middle of one end of the frame is set a ¾-inch pipe-threaded nipple, 6 or 7 inches in length, through which the steam is delivered into the pan. The nipple should project 3 inches from the box, to

afford a convenient attachment for the hose, and it should be held securely in place on the 2 by 4 inch end frame by lock nuts, closing on leather gaskets, as shown in figure 3.

The pan is placed on the bed, open side down, the hoop iron or angle bar cutting into the ground to form a knife joint, and the steam leaving the boiler under pressure enters the pan and quickly penetrates the soil.

The iron sterilizing pan which is sometimes used is similar to the wooden pan in shape and size. It has the advantage of lighter weight, making it easier to move. It is made of 16 or 18 gauge galvanized iron, supported by ribs of 1½-inch angle bars. The pan is made 4 inches deep, but 1½ inches should be added all around, to be turned in to serve as a flange on the bottom. To this flange is attached a 1½-inch angle iron, which rests upon the soil, forming the seal when the pan is placed upon the bed. The angle iron also serves as a rib for the lower part of the pan. Other ribs of angle iron are run across the top, two in the middle and one on each edge, holding the pan rigid. A ¾-inch nipple is firmly secured by flanges and solder in the middle of one end for the hose connection. Ring bolts for lifting are attached by flanges on the sides near the ends of the pan, which is rendered steam tight by close riveting and solder.



P1613T

FIG. 3.—Nipple inserted in the middle of one end of the frame of the sterilization pan. Note the leather gasket secured under the lock nut to prevent the escape of steam. Another gasket is similarly held by the nipple on the inside.

CARRYING OUT THE STEAMING PROCESS.

The boiler is placed close to the bed and where practicable at an equal distance from each end. Steam traction engines and portable boilers have a marked advantage, because they can be easily moved as the work progresses, allowing the use of a short pipe, giving a

minimum loss of heat by radiation. The pan is set on one end of a bed with its inlet nearest the boiler. The hose is attached to the pan and to the pipe leading from the boiler. Soil is banked around the edges of the pan to prevent the escape of the steam. The title-page illustration shows the boiler and apparatus connected for operation.

It is desirable to maintain a pressure in the boiler of 100 pounds, and if the pressure drops below 70 pounds the steam should be shut off, as this is the minimum for successful sterilization. Steam of high pressure has much greater penetrating power than steam of low pressure, and it is important to realize that the efficiency of the operation is greatly increased by dry high-pressure steam. A little experience in firing the boiler and operating the pan is necessary before one can maintain high pressure while supplying steam to the pan. Experienced operators can hold 100 to 125 pounds pressure for continuous operation 24 hours per day. The outlet valve should be opened only part way, so that the pressure of the boiler can be kept uniform and unnecessary blowing of the soil in front of the inlet prevented. A great volume of steam is not so essential as great penetrating power.

After 30 minutes the steam is shut off and the pan moved along the bed to the next area. One end of the pan should slightly overlap the area just steamed, thus leaving no strip unsterilized. Four attendants, one man at each corner, are usually required to lift the pan, using bars or ax handles inserted through the ring bolts. Immediately after moving the pan, the steamed area is covered with a canvas or burlap blanket. This is important, because the heat must be conserved in the surface soil to allow it to reach the lower soil by conduction. It is desirable that covers be supplied for the entire bed, so that each area will be covered for several hours after steaming.

Experienced operators have found it advantageous to use two pans alternately, eliminating the necessity of moving the pan immediately after the steam is shut off. The moving of the pan immediately after operation is quite disagreeable to the workers because of the volume of steam held under the pan. There is also a considerable loss of heat when the pan is moved before the heat has reached the lower soil layers.

TEMPERATURES SECURED.

In sandy soils, after 30 minutes' steaming, the temperatures to be expected in the upper 2 inches of soil directly under the pan are approximately 208° to 212° F., at 3 to 4 inches 170° to 180°, and at 6 inches 120°. Two hours after the removal of the pan the temperature at 6 inches should be about 160° F. If a thermometer is not available, the efficiency of the steaming operation can be easily determined by burying a potato 4 inches under the surface of the soil. The potato should be well cooked when the pan is removed, and this is a common

method of determining the work done by a steaming outfit. Although the temperatures reached directly under the pan are quite high, little heating effect is to be noted away from the edges of the pan.

Clay soils, because of their heavier texture, require longer periods for steaming than sandy soils. Steam penetration and heat conduction are not as rapid as in the more open sandy loams, and it is especially important that these soils be as dry as possible at the time of steaming. The moistening of the soil by rainfall or snow just before steaming prevents the rapid heating of the soil and the full penetration of the steam, and the efficiency of the work is greatly reduced.

COST OF STEAMING.

Contractors who furnish the boiler and a fireman may charge according to the area steamed at an average rate per 100 square feet, or they may charge a flat daily rate. The charges for this work vary in the several tobacco-growing sections, ranging from 50 cents to $1 per 100 square feet, or from $6 to $12 a day, and the contractor may or may not furnish the pan and fuel.

The fuel consumption is usually reckoned at one-half ton of soft coal for every 1,000 square feet of seed bed.

Where the grower owns the boiler, the costs of operation are somewhat lower. The average area covered in a 10-hour day is 1,000 square feet and the cost is approximately $6. It is also better to use two pans, so that there may be no delay in steaming due to the shifting of the pan. One attendant is required constantly to fire the boiler; three others must be ready at intervals during the day to help him move the pans.

The labor cost can be reduced considerably by using a rack for lifting the pan. For this rack two pairs of buggy or light wagon wheels set on axles a little longer than the width of the pan are joined together by a light frame. This frame should be 4 feet shorter than the pan. A long rod or lever is attached in the middle of each end of the frame, to allow for the easy lifting of the pan. The lever is provided with a hook at the end of its resistance or lifting arm. To the ring bolts at each end, a substantial rope is fastened with sufficient play for the hook of the lever to hold the rope conveniently. By hooking the rope and using the frame of the carriage as a fulcrum, the pan is lifted. The lever arms can be hooked in position by a wire or clutch after the pan is lifted. The sides of the seed-bed frame form a guide for the wheels, thereby making it a simple operation for one man to handle and move a pan.

On account of the possible occurrence of rains and snows during the period for sterilizing, it is advantageous even on small farms to operate 24 hours per day in favorable weather. Large growers do this because of the convenience and economies in fuel and labor.

The permanent seed beds are usually equipped with a water-supply system; where this is not the case the transportation of water for the boiler is an additional item of expense.

In considering costs, one should bear in mind the fact that a thoroughly steamed seed bed is practically free from weed seeds, thereby eliminating the cost of weeding. The amount saved in weeding will probably more than cover the cost of sterilization, as two good weedings usually cost more than $6 per 1,000 square feet. Figure 4 illustrates the effectiveness of the steaming-pan method in killing weed seeds. On the right of the partition it will be seen that the sterilized area is practically free from weeds, whereas the unsterilized portion on the left was worthless because the weeds had forced out nearly all of the tobacco plants. Additional advantages are that the plants are more vigorous and are ready for transplanting 10 to 14 days earlier than plants in unsterilized beds. As has been stated, where root-rot or other fungous diseases are present, some form of

P1645T

FIG. 4.—A tobacco seed bed, showing a partition between the steamed and the unsteamed portions. Both sections were sown at the same time with similar seed, but the weeds in the unsteamed section (at the left) practically killed the tobacco seedlings. No weeds grew on the steamed part.

sterilization is essential for the production of healthy seedlings, and steaming is decidedly the most effective process yet developed for insuring the elimination of these diseases.

IMPORTANT CONSIDERATIONS.

Sterilization so improves the soil conditions that less fertilizer is necessary than on unsterilized ground. One should exercise caution against reinfecting the soil by walking on the steamed bed, using infected rakes, water from stagnant ponds, a solution of manures, or seed sown with unsterilized vegetable matter, such as decayed wood, punk, or decomposed leaf tissue. Finely sifted raw bone meal, thoroughly sterilized punk, and land plaster are excellent materials for spreading the seed. They should be very slightly moist to spread well between the fingers and to retain the seed in the mixture. Root-rot is found in some seed beds that have been thoroughly steam sterilized. Such infection may have been carried by fertilizers applied after the steaming, by decayed vegetable matter used to spread

the seed in sowing, or by contamination with adjoining diseased soil if the bed has not been kept covered after having been sterilized. Diluting material, like punk, can be readily sterilized at the time of steaming the soil by placing it in a bucket inserted under the pan, or it may be kept in the oven of a kitchen stove for several hours at a moderate temperature.

The seed may be safely sown 12 hours after the steaming of the beds. Dry seeds only should be used. There is a temporary injurious action in the soil after steaming which retards the growth of the young plant for 10 to 14 days and sometimes longer. Sprouted seed is more readily injured by this temporary effect of steaming, but when dry seed is sown the effect has largely disappeared when the first shoots appear. This condition may sometimes retard the development of the plants appreciably during the first three weeks after sowing, but this is followed by a decided stimulating action, so that plants in sterilized beds are usually ready for setting two weeks earlier than plants on unsteamed beds.

Steamed seed beds require much more water to produce a crop of seedlings than untreated seed beds. The surface soil is inclined to dry or crumble, and because of this tendency it is advisable to locate the seed beds near an easily available water supply. During clear, bright weather the beds should be inspected late in the morning and again in the middle of the afternoon, as the soil is very likely to dry out, killing young seedlings. Because steamed soil requires larger quantities of water the tendency is to overwater. In this, care must be used, especially if the beds are sown rather thickly, since there is danger of the occurrence of damping-off under certain conditions. It is an advantage to keep the seed beds occupied after the tobacco plants are taken off. Steamed beds are especially adapted for growing late vegetable crops, which practice tends to keep the beds free from weeds.

THE FORMALDEHYDE METHOD OF STERILIZING SEED BEDS.

When steam sterilization can not be used, formaldehyde may be employed to control seed-bed diseases. One gallon of commercial 40-per-cent formaldehyde solution is diluted in 50 gallons of water. This solution is applied at the rate of 2 quarts per square foot of seed bed, using a common sprinkling can.

The seed bed should be prepared for sowing, and to do the most effective work the soil should be dry enough to absorb all of the formaldehyde solution. To prevent the washing of the soil, the necessary quantity should be put on in a number of applications at intervals of, say, 20 to 30 minutes. When all the solution is absorbed the bed should be covered with blankets for 24 hours to

confine the fumes. It should then be aired for 8 or 10 days to allow the escape of the fumes from the soil. The seed should not be sown so long as there is a trace of the formaldehyde, for this will kill the germinating seed or young seedlings.

The use of formaldehyde is recommended only when steam sterilization is not practicable. Its cost is greater than the cost of steaming, and it is usually less effective.

APPLICATION OF THE STEAMING PROCESS TO CROPS OTHER THAN TOBACCO.[1]

The steaming of greenhouse soils with coils of pipes embedded therein had been practiced for a number of years prior to the development of the inverted-pan method of steaming as applied to tobacco seed beds. Since its adoption on tobacco seed beds the inverted-pan method of steaming has been demonstrated to be effective for greenhouse work, and, further, it is easily seen that the method can be applied to hotbeds and coldframes for various other crops. It is especially valuable in the production of vegetable crops where it is desired to control damping-off and other fungous diseases which may be in the soil. The special requirements for any particular situation will readily suggest themselves, and the apparatus described for tobacco seed beds can be easily modified in size and shape of pan and arrangement of piping to suit almost every condition of soil steaming in greenhouses, outside frames, or even in open fields.

[1] It is upon the suggestion of Dr. W. A. Orton, Pathologist in Charge of Cotton, Truck, and Forage Crop Disease Investigations, that the attention of the truck grower is directed to the application of the inverted-pan method of steaming for the control of certain vegetable diseases.

THE FARMERS OF THIS COUNTRY are as efficient as any other farmers in the world. They do not produce more per acre than the farmers in Europe. It is not necessary that they should do so. It would perhaps be bad economy for them to attempt it. But they do produce by two to three or four times more per man, per unit of labor and capital, than the farmers of any European country. They are more alert and use more labor-saving devices than any other farmers in the world. And their response to the demands of the present emergency has been in every way remarkable. Last spring their planting exceeded by 12,000,000 acres the largest planting of any previous year, and the yields from the crops were record-breaking yields. In the fall of 1917 a wheat acreage of 42,170,000 was planted, which was 1,000,000 larger than for any preceding year, 3,000,000 greater than the next largest, and 7,000,000 greater than the preceding five-year average.

But I ought to say to you that it is not only necessary that these achievements should be repeated, but that they should be exceeded. I know what this advice involves. It involves not only labor, but sacrifice; the painstaking application of every bit of scientific knowledge and every tested practice that is available. It means the utmost economy, even to the point where the pinch comes. It means the kind of concentration and self-sacrifice which is involved in the field of battle itself, where the object always looms greater than the individual. And yet the Government will help, and help in every way that is possible.—From President Wilson's Message to the Farmers' Conference at Urbana, Ill., January 31, 1918.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1918